Tools and Concepts for Traffic Flow Management

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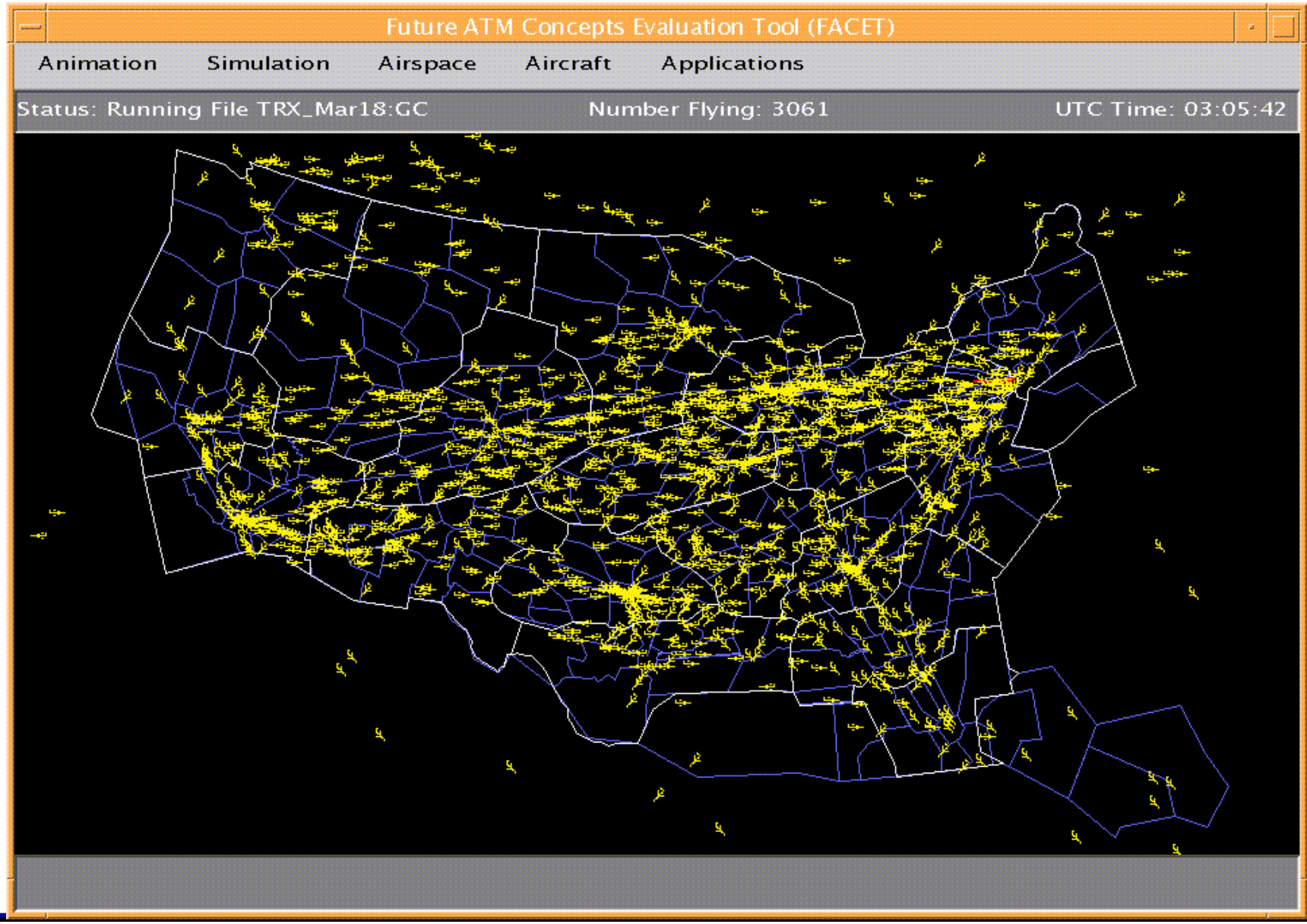
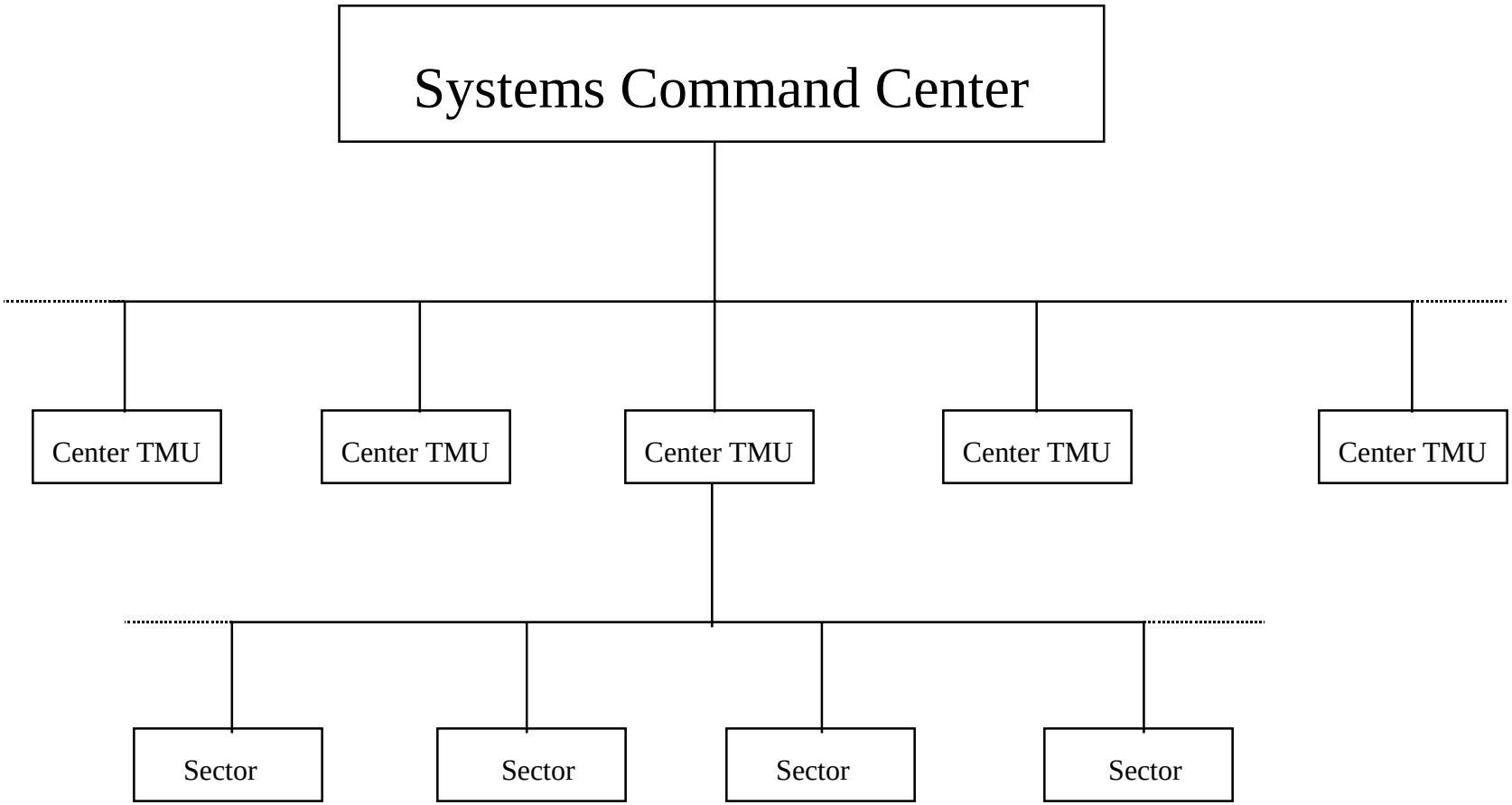
Traffic Flow in NAS



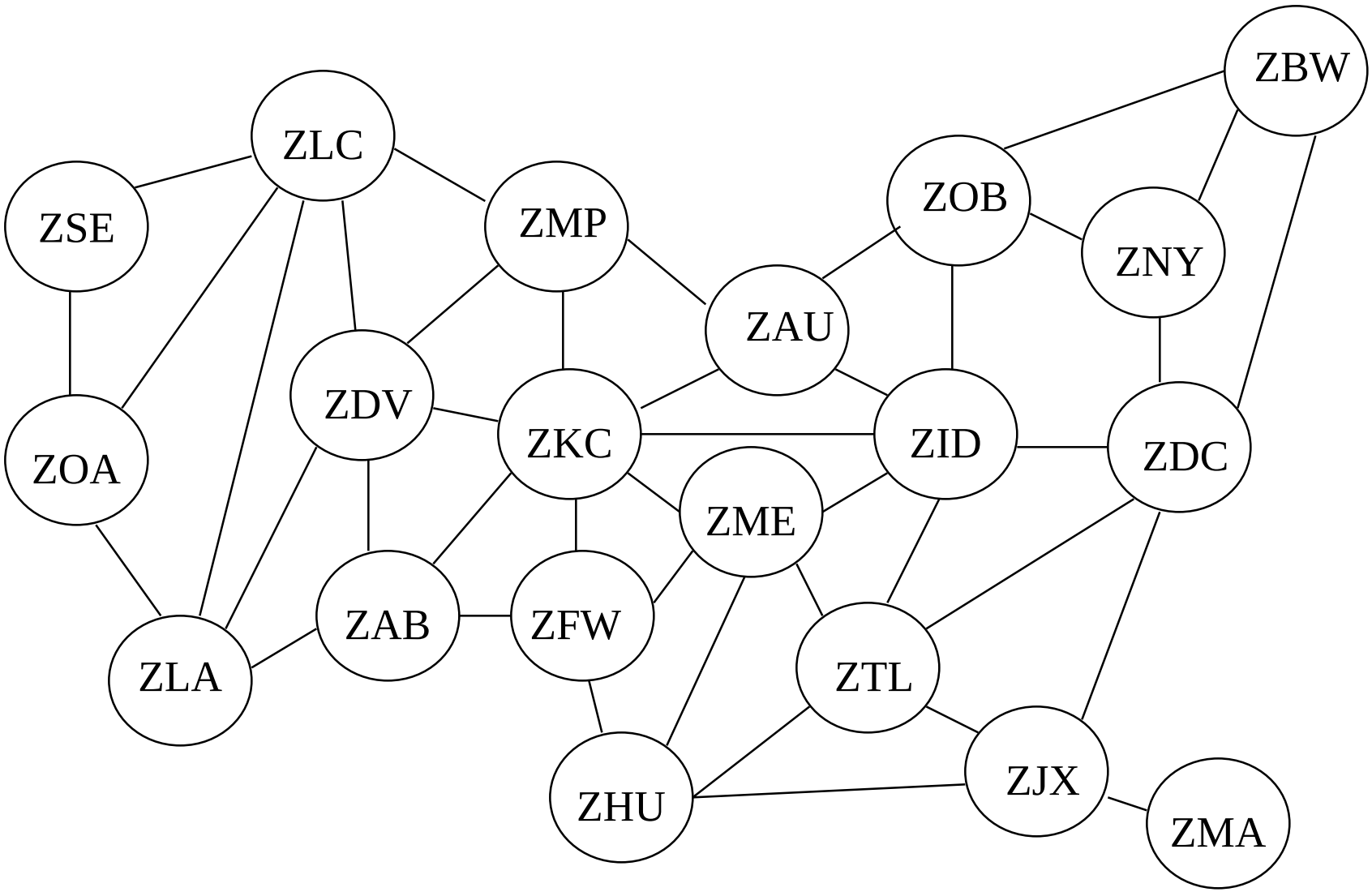
TFM Structure



-Sector Controllers responsible for traffic separation

- SCC and TMU responsible for smoothflow of traffic without overloading sectors

Inter-Center Traffic Flow



Attributes of TFM

- Long planning horizon (6-Plus hours)
- Large number of aircraft and competing goals
- Uncertainties
  - Implementation (information exists, but not available to the DM or automation e.g. aircraft weight, departure times, cancelled flights, pop-up flights..)
  - Understanding (Weather prediction)
- Large variation in Traffic demand and capacity
- Competing interests/goals

What Improvements are needed? NASA AvSTAR Workshop, Sep 20-21, 00

- Provide tools to frequently update strategic planning with and tactical operations decisions
- Develop metrics for Controller workload (Dynamic Density) and feasible capacity of TFM under ATC, user-preferred and actual conditions
- Provide a forecast of the traffic flow conditions to all users and decision makers (AOC, ATCSCC, Regions)
- Move from “reactive” TFM strategies to “proactive” TFM strategies
- Improve the reliability of sector monitor alerts
- Create a unified TFM

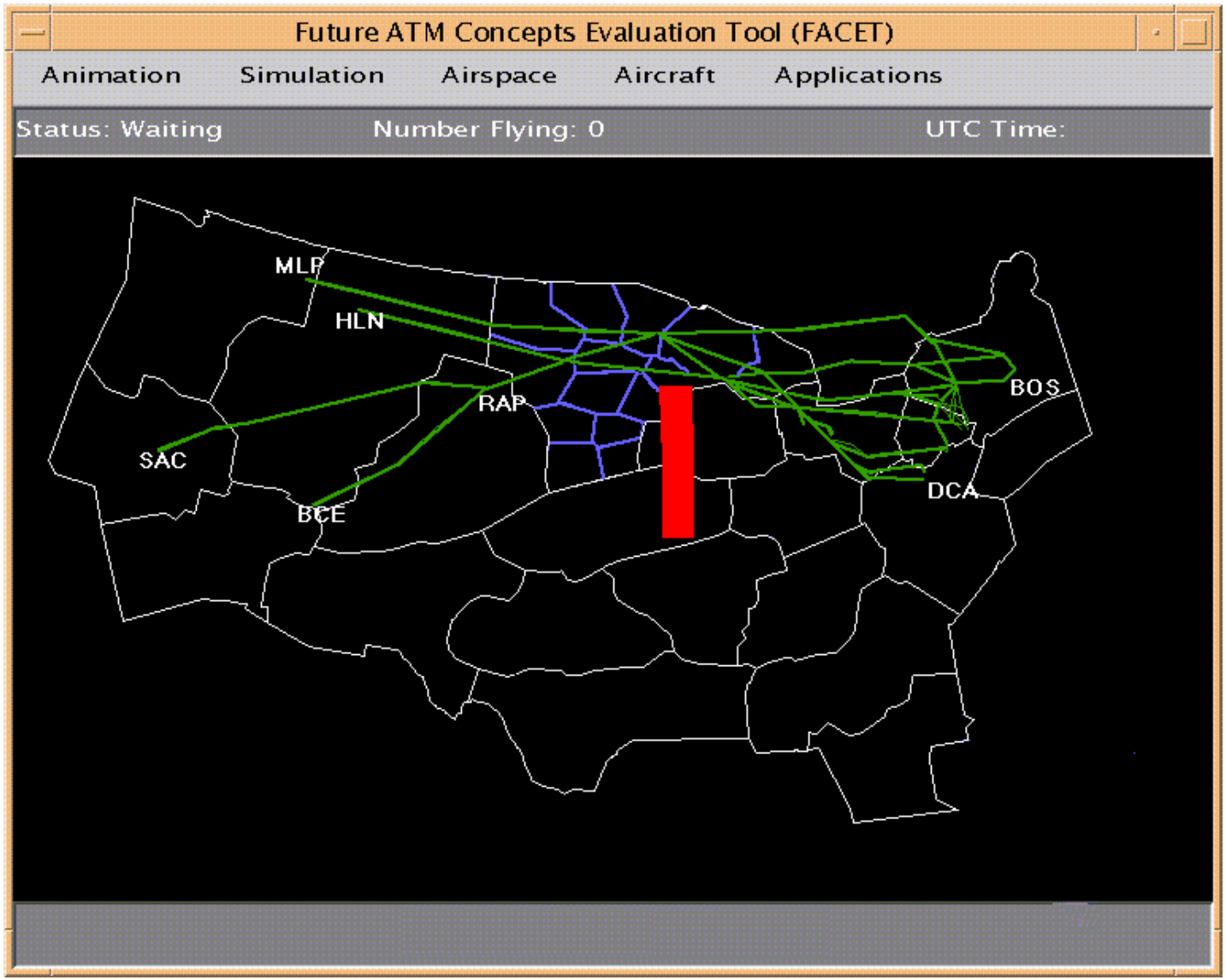
Types of Control (TFM actions)

- **Ground Delay Program**
  - Controlling aircraft departure time to manage aircraft arrival rates
- **Metering (Miles-in-Trail)**
  - Controlling flow of aircraft into a center by imposing flow restrictions on aircraft one or more centers away
- **Reroutes**
  - Congested En-route area
  - Weather
  - Special Use Airspace
- **Playbook**
  - Effort to provide a common understanding of re-routing strategy under previously defined situations

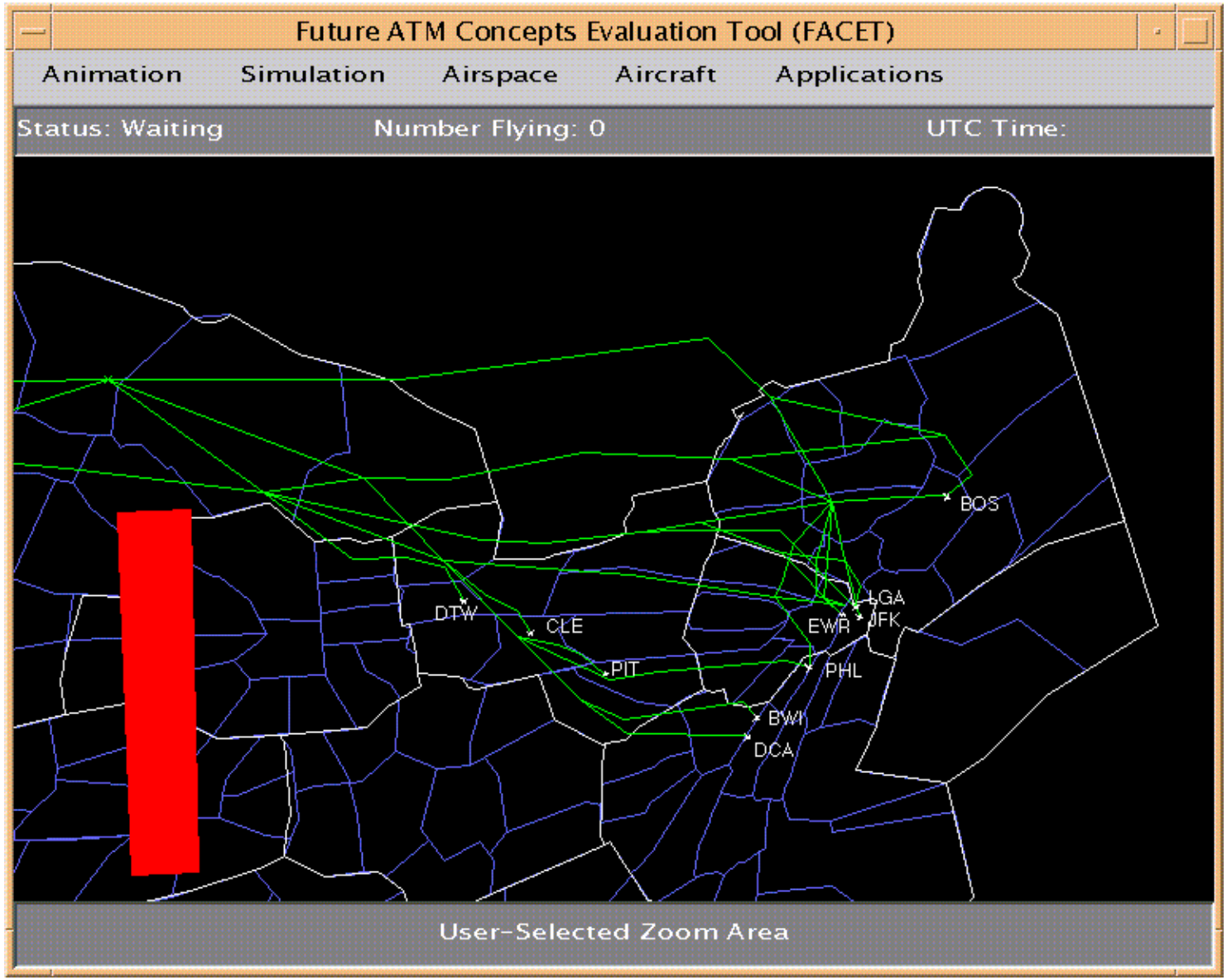
Tools and Concepts for Traffic Flow Management

- **Objective: Develop tools and concepts to integrate various TFM actions to improve traffic flow management**
- **Approach: Address the problem at the systems level by taking advantage of CTAS trajectory modeling capabilities and research on human factors**
- **Current Research:**
  - **Strategic TFM**
  - **Local TFM**
  - **Future ATM Concepts Evaluation Tool (FACET)**
  - **Dynamic Density**
  - **TFAS**

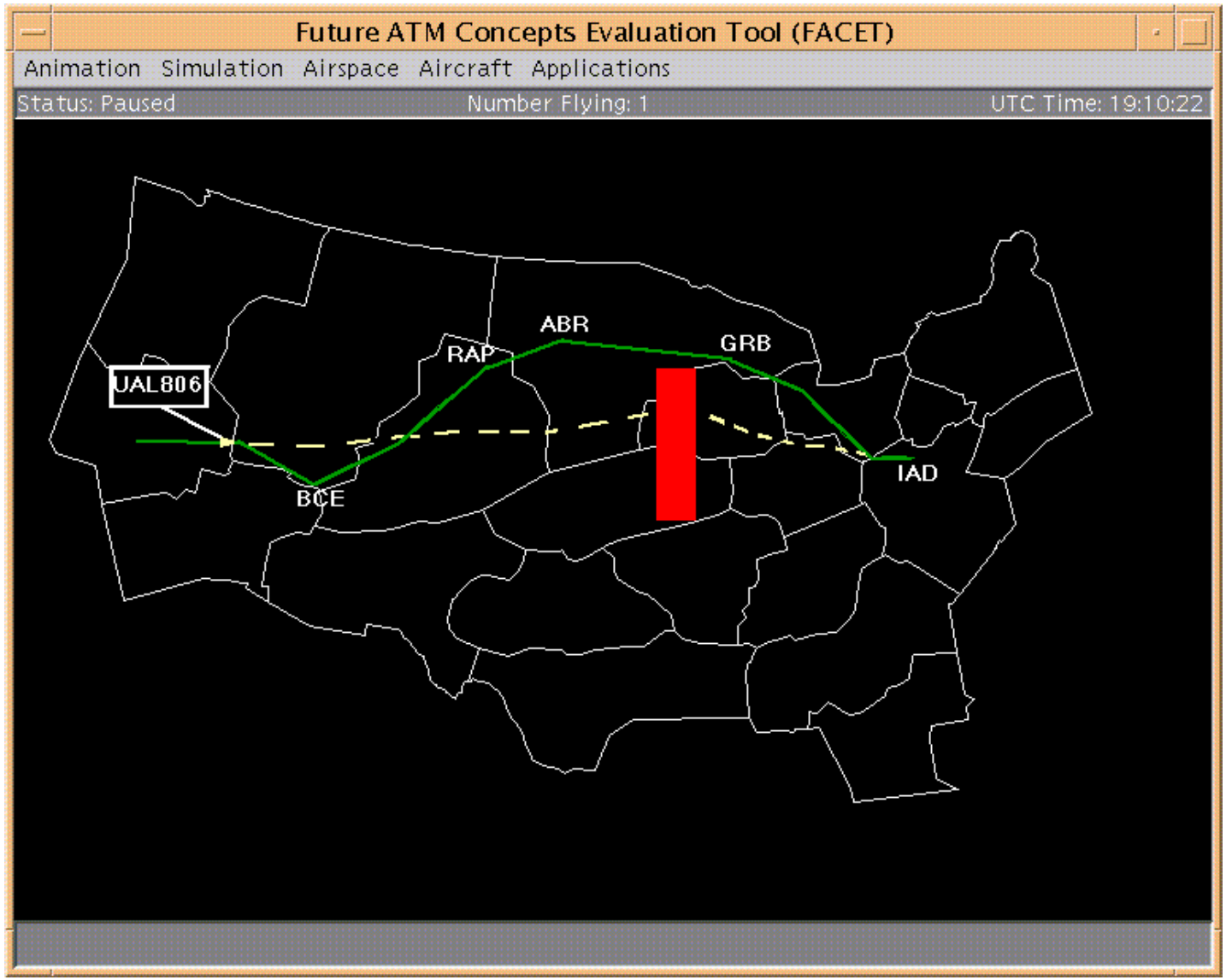
ZMP Plan#1


Future ATM Concepts Evaluation Tool (FACET)
Animation
Simulation
Airspace
Aircraft
Applications
Status: Waiting
Number Flying: 0
UTC Time:
MLP
HLN
RAP
SAC
BCE
BOS
DCA

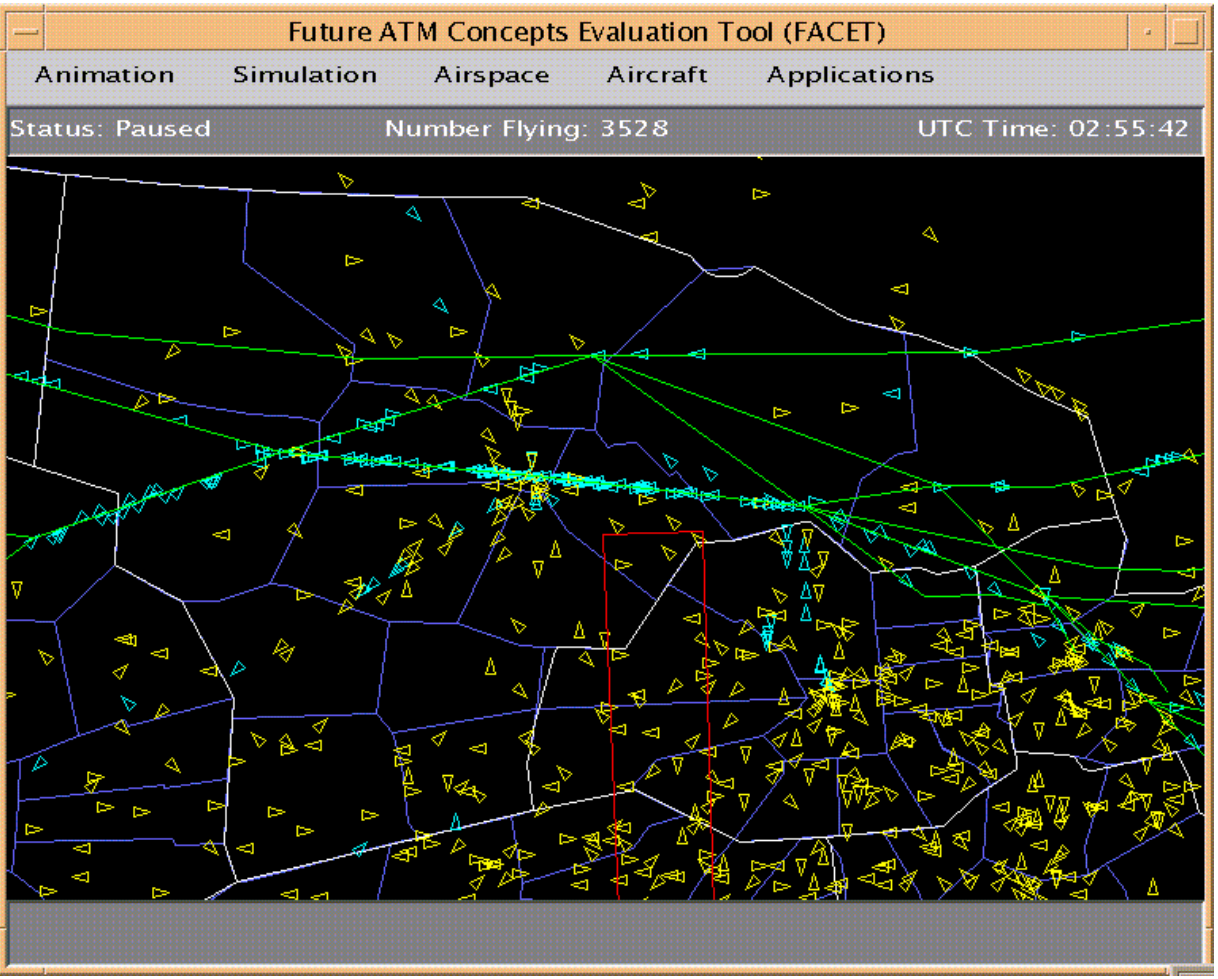
ZMP Plan #1 - Arrival Routes

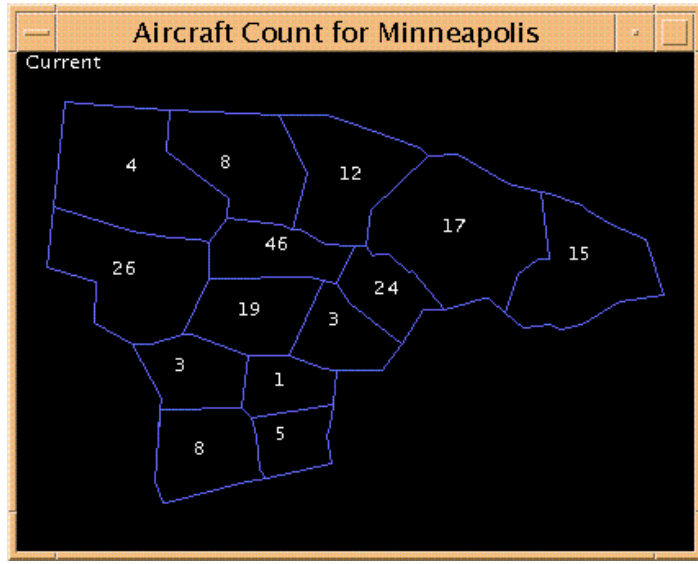


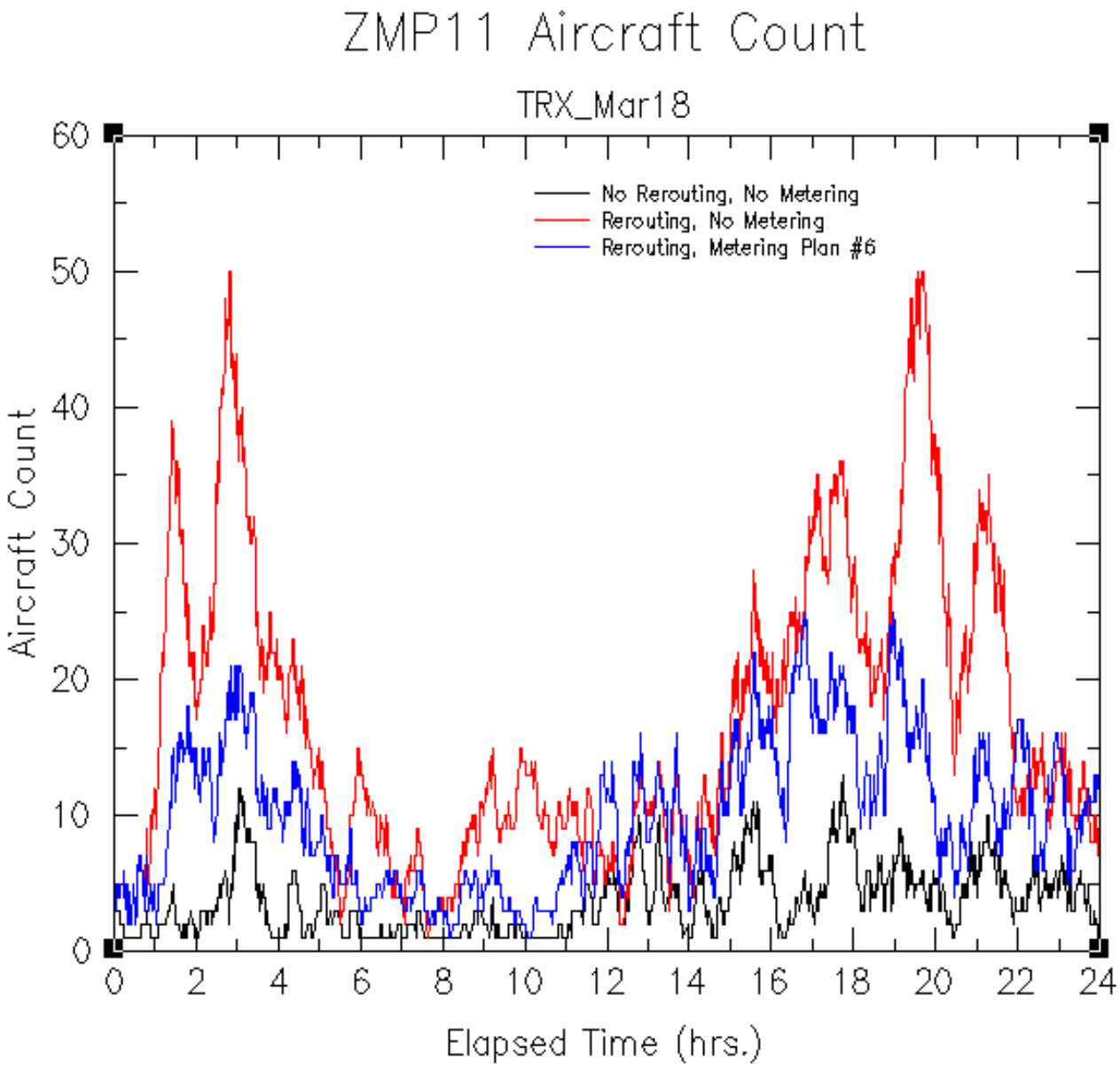
Impact on aircraft route



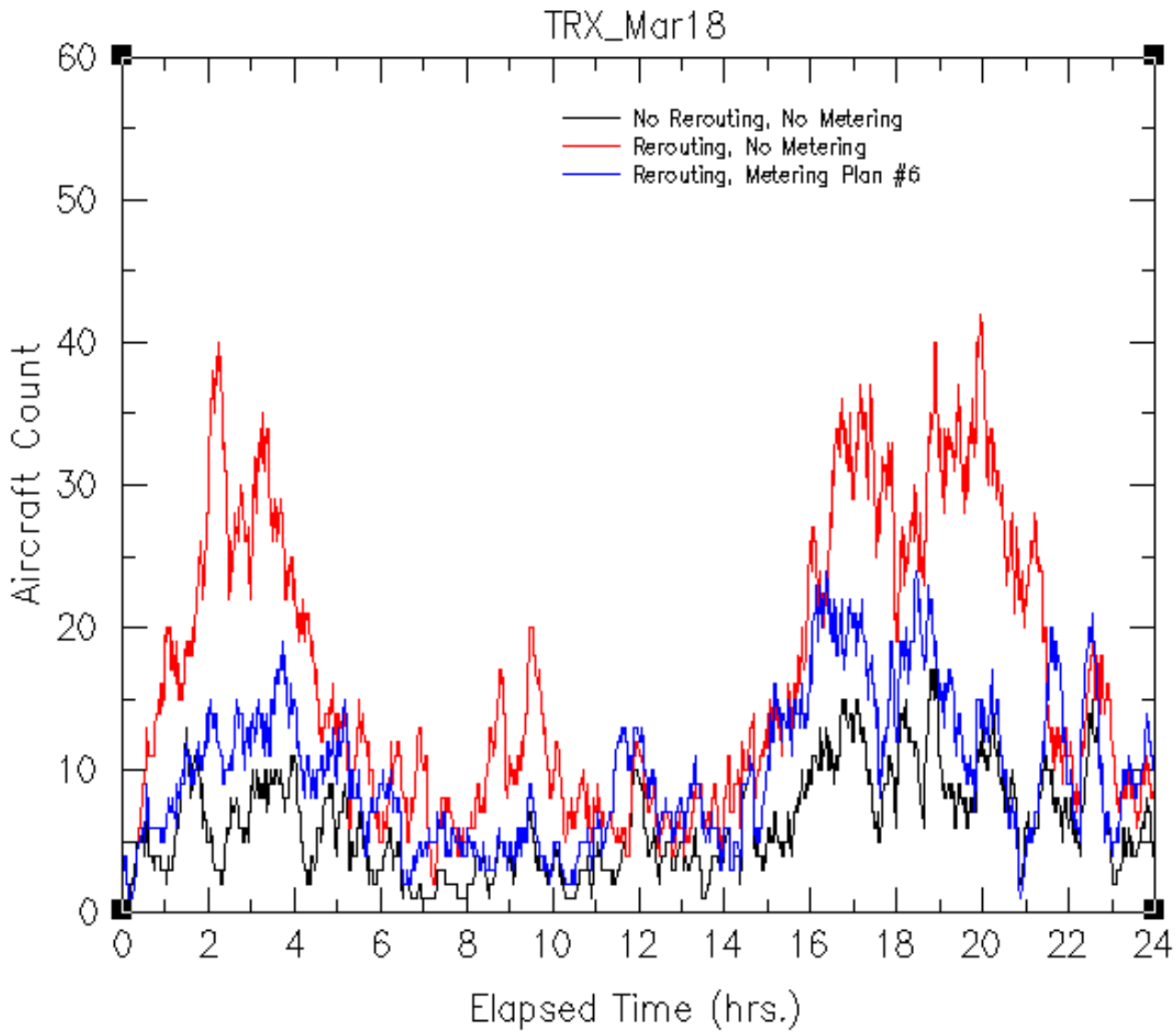
ZMP Plan #1 with Sector Count



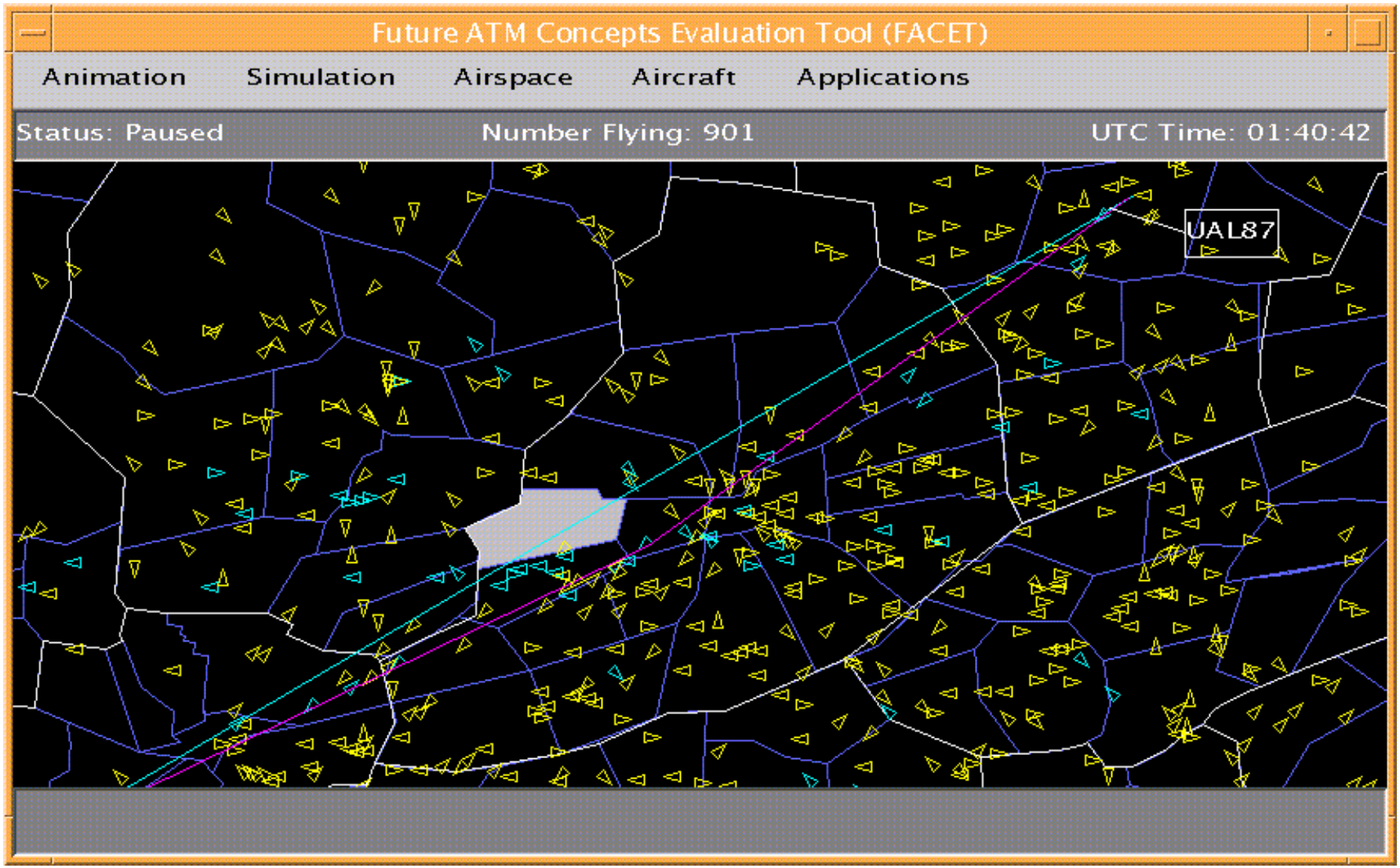



ZMP11 Aircraft Count
TRX_Mar18
No Rerouting, No Metering
Rerouting, No Metering
Rerouting, Metering Plan #6
Aircraft Count
Elapsed Time (hrs.)
0
10
20
30
40
50
60
0
2
4
6
8
10
12
14
16
18
20
22
24

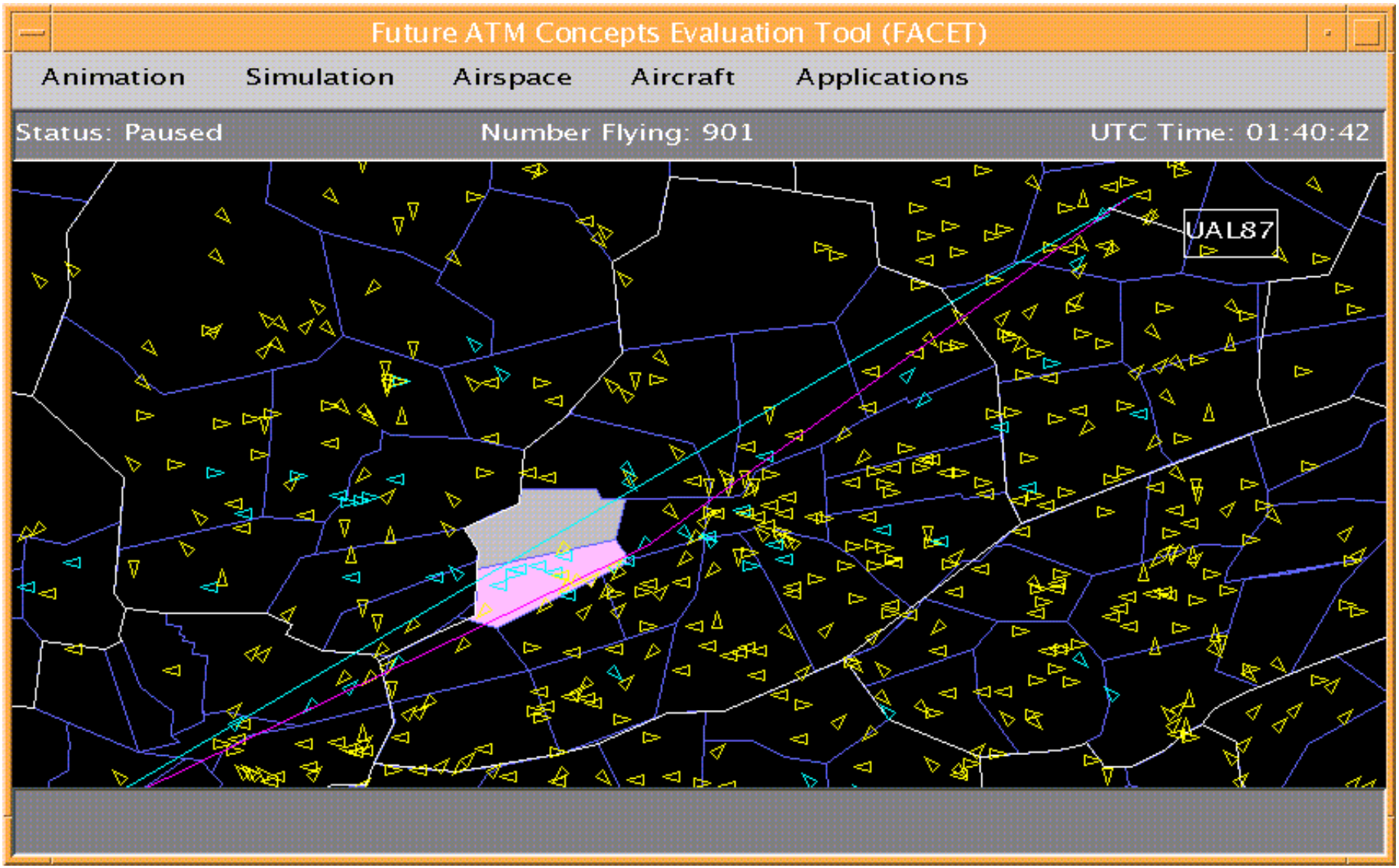
ZMP20 Aircraft Count



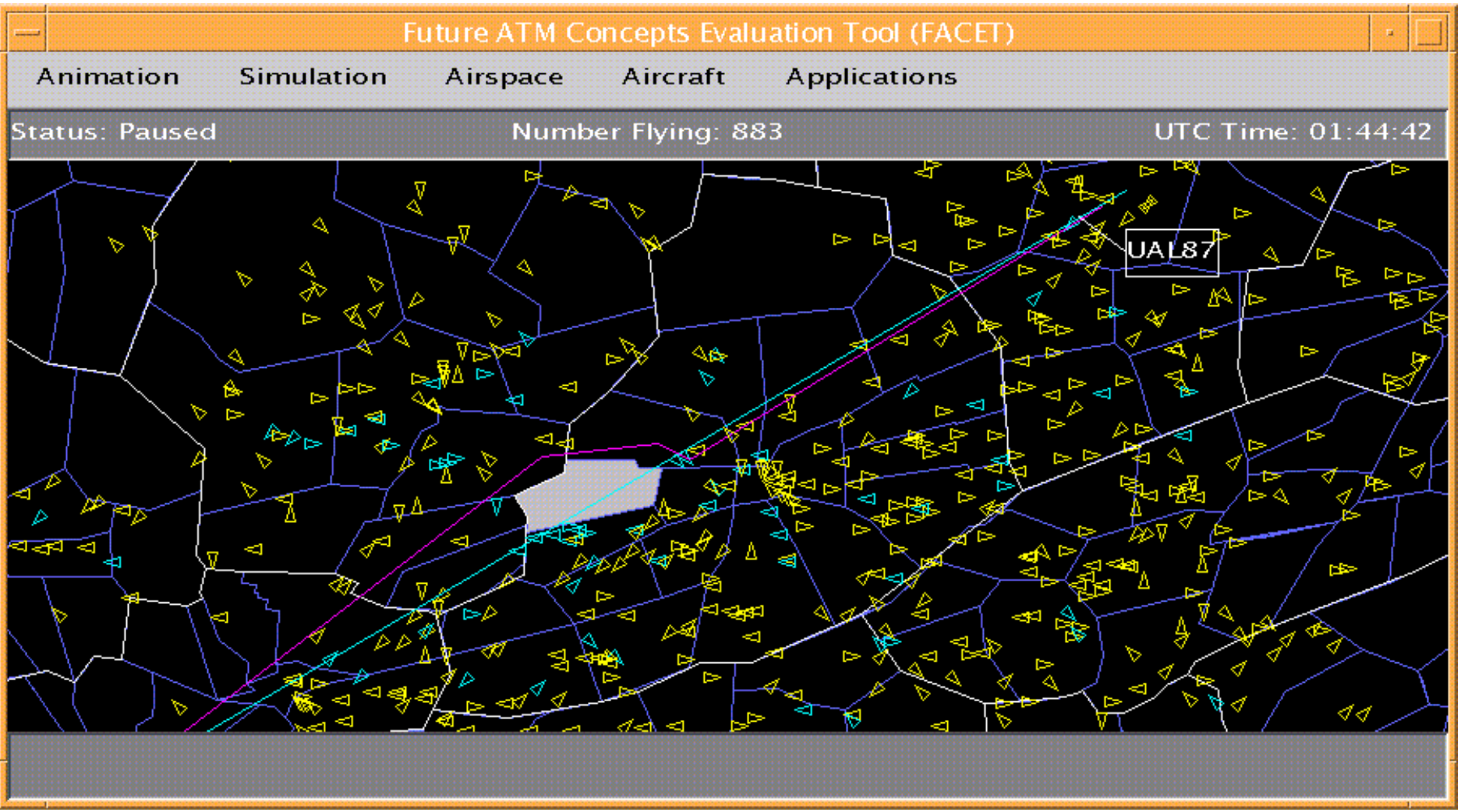
Re-routing to Avoid Sector 3



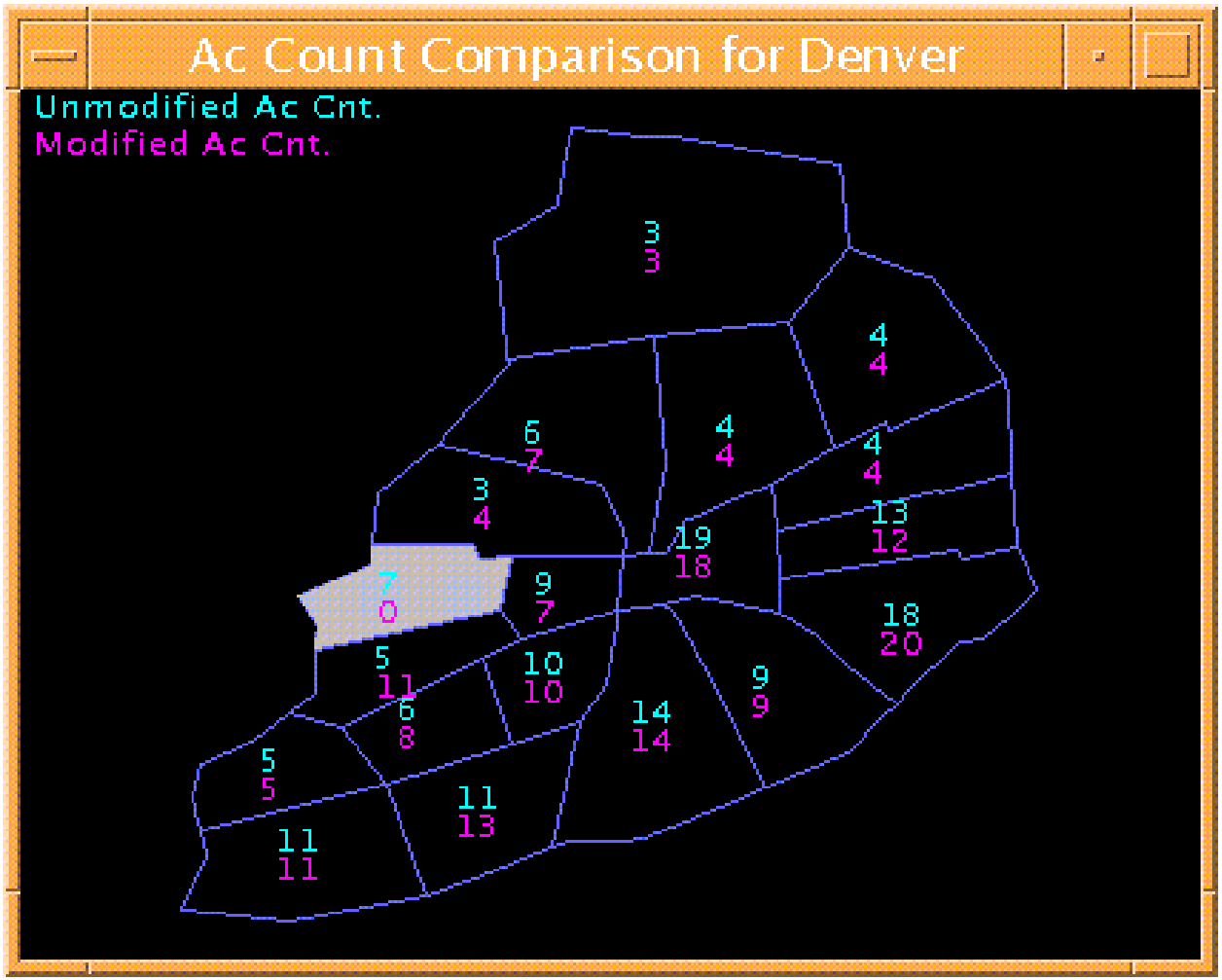
Effect of Re-routing On Sector 4



Re-routing with no sector overloading

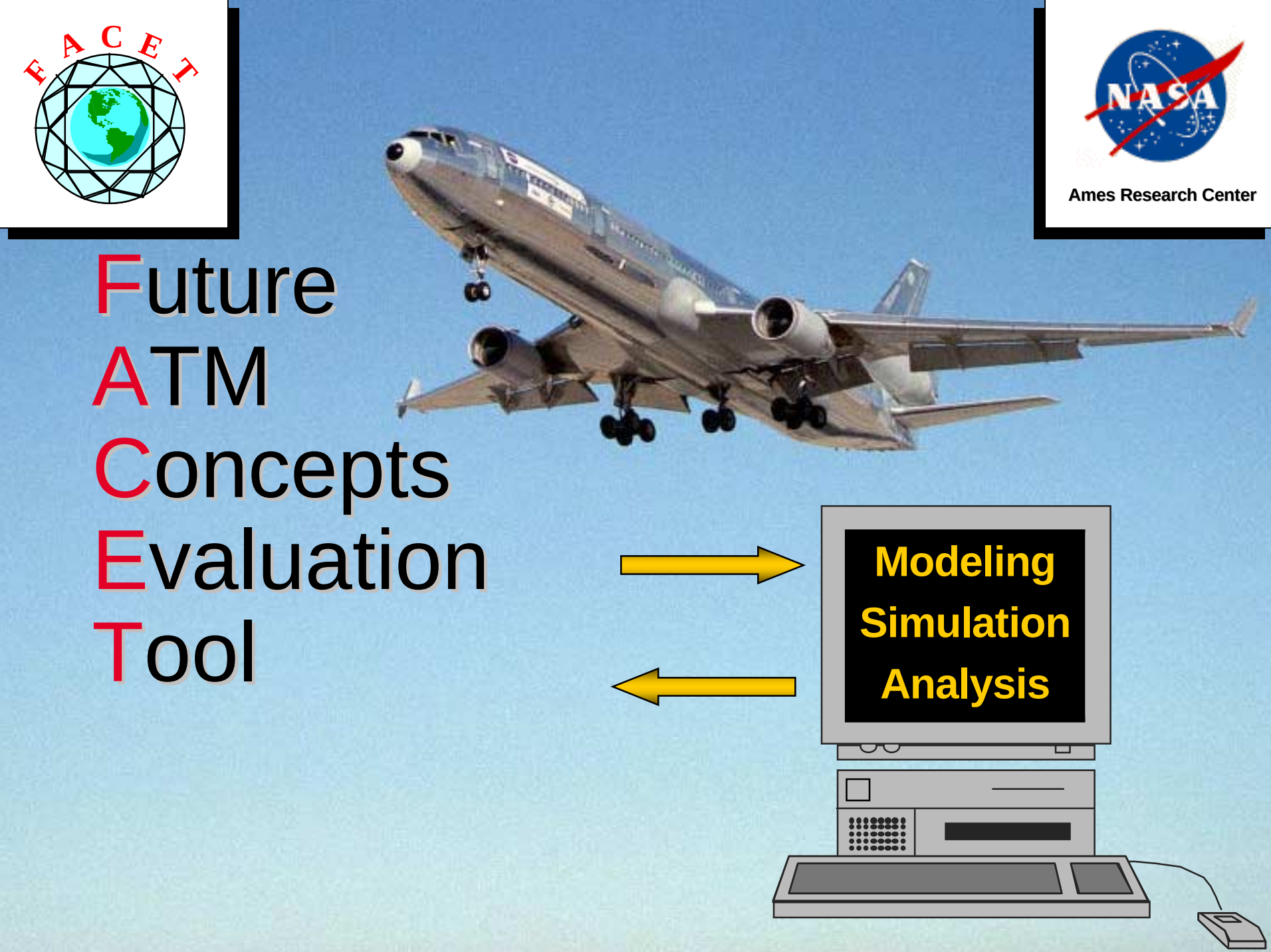


Change in Traffic Density



TFM tools

- **Enhanced Traffic Management System (ETMS)**
  - Backbone of TFM
  - 4-5 minute update of track positions from Host
  - 1 minute update of track positions from major TRACONs
  - Weather Display
  - Moniter Alert
- **Collaborative Routing Coordination Tool (CRCT)**
  - Display Flow Constrained Areas
  - Identify affected aircraft
  - Re-route strategy: What-if sector counts and future positions
- **Flight Schedule Monitor (FSM)**
  - Provides ground delay programs for airports.
- **TFAS**
- **FACET**


FACET
NASA
Ames Research Center
Future
ATM
Concepts
Evaluation
Tool
Modeling
Simulation
Analysis

Introduction to FACET

- **Simulation tool for exploring advanced ATM concepts**
  - **Flexible environment for rapid prototyping of new ATM concepts**
  - **Interface with Host and ETMS data**
  - **Hierarchically compatible with CTAS in scope and fidelity**
- **Balance between fidelity and flexibility**
  - **Model airspace operations at U.S. national level (up to 5,000 aircraft)**
  - **Modular architecture for flexibility**
  - **Software written in "C" and "Java" programming languages**
    - » **Easily adaptable to different computer platforms**
    - » **Runs on Sun, SGI, PC and Macintosh computers**
  - **Can be used for both off-line analysis and real-time applications**
- **Current uses of FACET**
  - **Benefits Study of CTAS Direct-To Tool**
  - **Tools for Traffic Flow Management**
  - **Space Launch Vehicles operation in the Airspace**
  - **Distributed Air-Ground Separation Methods**
  - **Visualization of Air Traffic Data**

Principal Functionalities

- **Modeling of en route airspace over the entire continental U.S.**
  - **Center and sector boundaries**
  - **Special Use Airspace boundaries**
  - **Jet Routes and Victor Airways**
  - **Locations of navaids and airports**

- **4D trajectory modeling capabilities**
  - **Global Co-ordinate System**
  - **Fly flight-plan routes or direct (great circle) routes over round earth**
  - **Climb/descent performance models for 66 aircraft types, mapped to over 500 aircraft types**
  - **Dynamic models for turns and acceleration/deceleration**
  - **Weather models (e.g., wind, convective cells)**
  - **Ability to add new class of vehicles (e.g., space launch vehicles)**

FACET complements CTAS

Feature	FACET	CTAS
Trajectory Modeling	Simplified 3-DOF model (climb rate/speed tables)	Point-mass 3-DOF model (thrust and drag models)
Airspace Modeling	ARTCCs only	ARTCCs and TRACONs
Flight Plan Processing	Yes	Yes
Weather Modeling	RUC-2	RUC-2
Modeling Scope	National Airspace (~ 5,000 aircraft)	Center Airspace (~ 500 aircraft)
Co-ordinate System	Global	Center
Computer Platform	Single desktop computer (e.g., Sun, SGI, Mac, PC)	8 to 10 networked Sun workstations

FACET

- **Development of FACET to evaluate the results of TFM initiatives such as Playbook, Miles-in-Trail, GDP, etc using ETMS data**
  - **Playbook**
  - **Metering**
  - **Live ETMS**
  - **Predictions**

FACET Status

- **Playbook**
  - Implemented several plays
  - Partial automation of plays
- **Metering**
  - Miles-in-Trail specified at any fix
- **Live ETMS**
  - Connected to live ETMS
  - Separation of PGUI from computing part
  - Include ETMS decoder directly
  - 90% done
- **Predictions**
  - Addition of crossing restrictions (LOA and SOP)

Discussion

- **Functionality has been developed for starting interaction with TFM operators and experts**
- **Further development requires scenarios, special procedures, etc to make the algorithms handle operational conditions**
- **Other technical issues**